

Risk to Oregon's Energy Sector

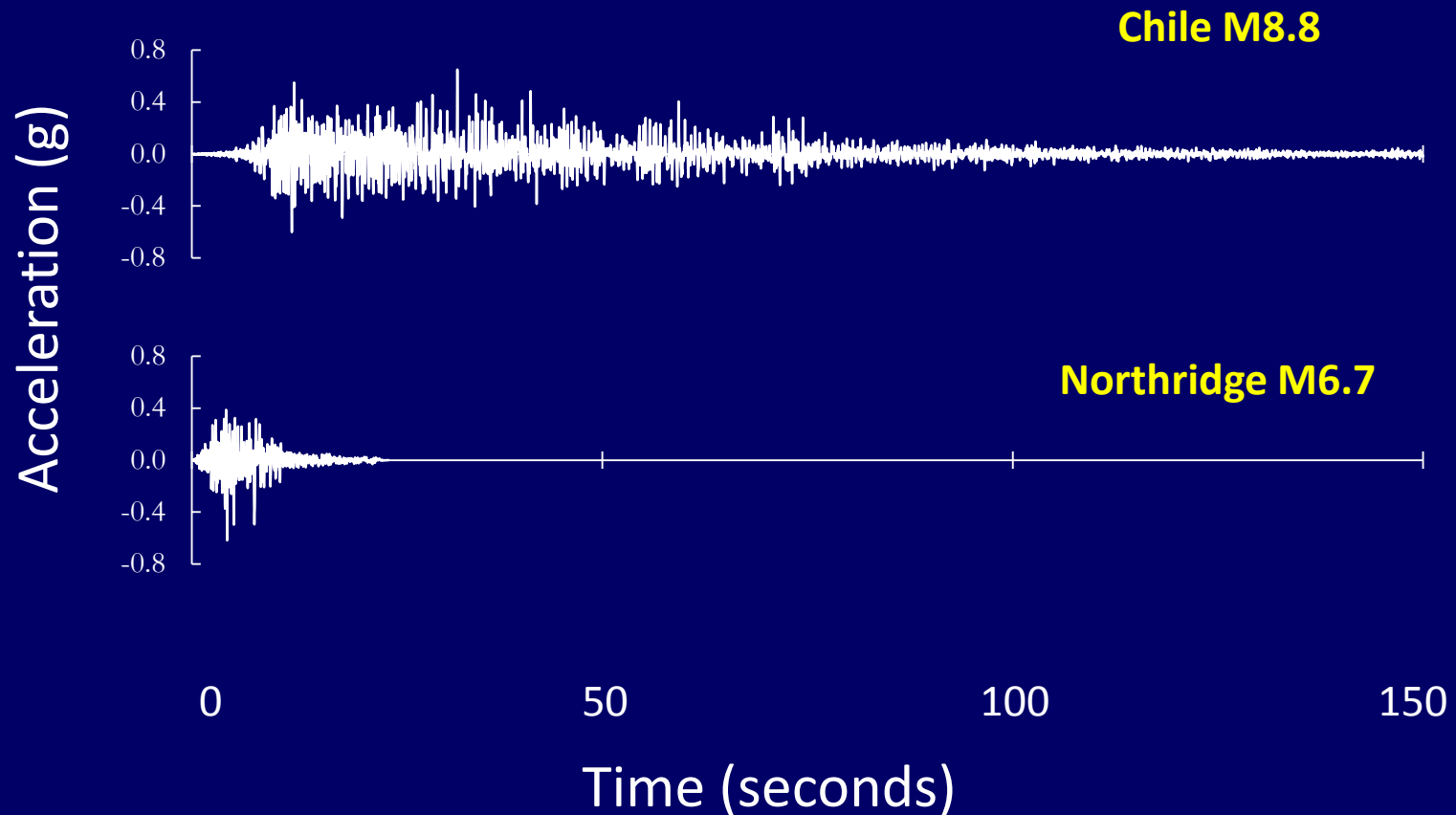
Yumei Wang, DOGAMI Geohazards Engineer, PE

April 5, 2016 NIST Community Resilience Panel



Source: DHS 2011
Analytical Baseline
Study

Shaking Duration: Subduction Zone Magnitude 9 vs. Crustal Fault



Source: D. Baska, Terracon



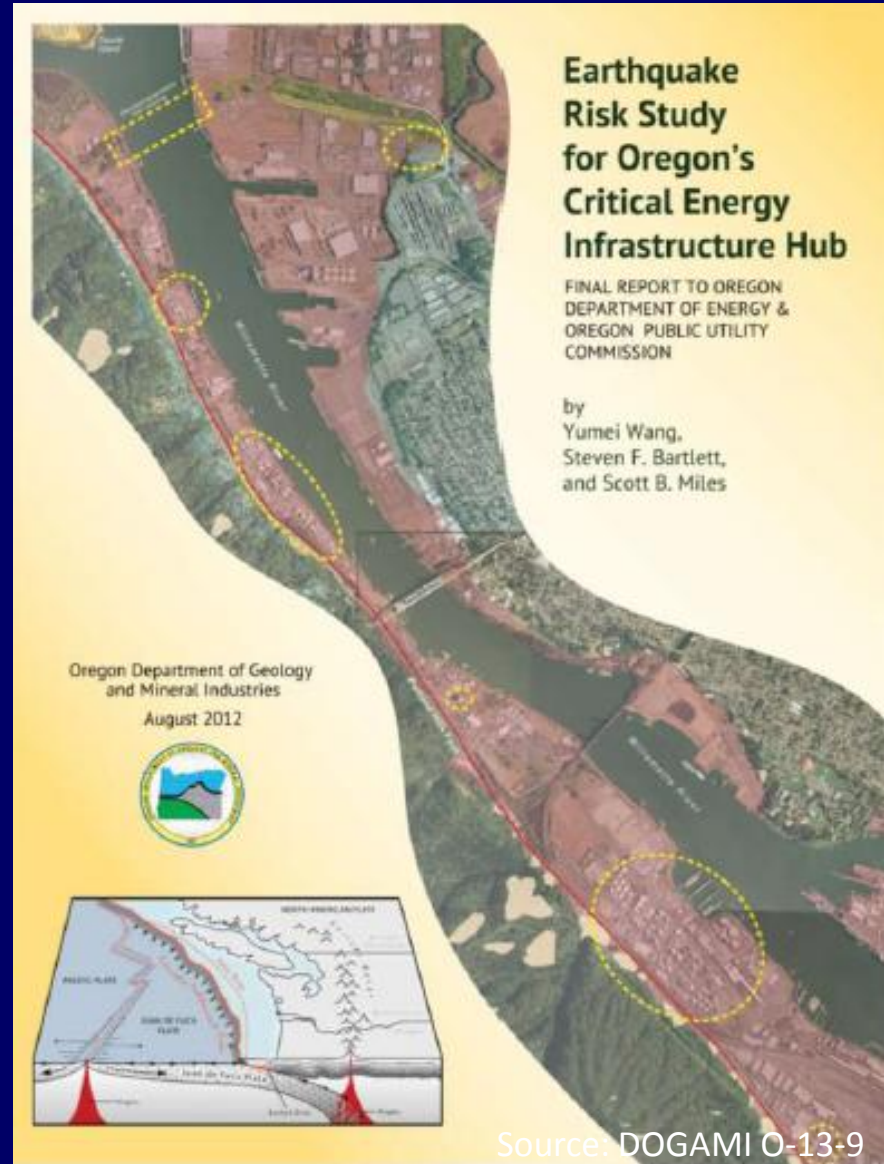
Resilience Planning in Energy Sector

Online at Oregon Dept of Energy and Oregon Public Utility Websites

**5-yr effort:
OR Dept Energy,
OR PUC, and
DOGAMI**

**2013 DOGAMI
earthquake study**

4/18/2016 Y. Wang

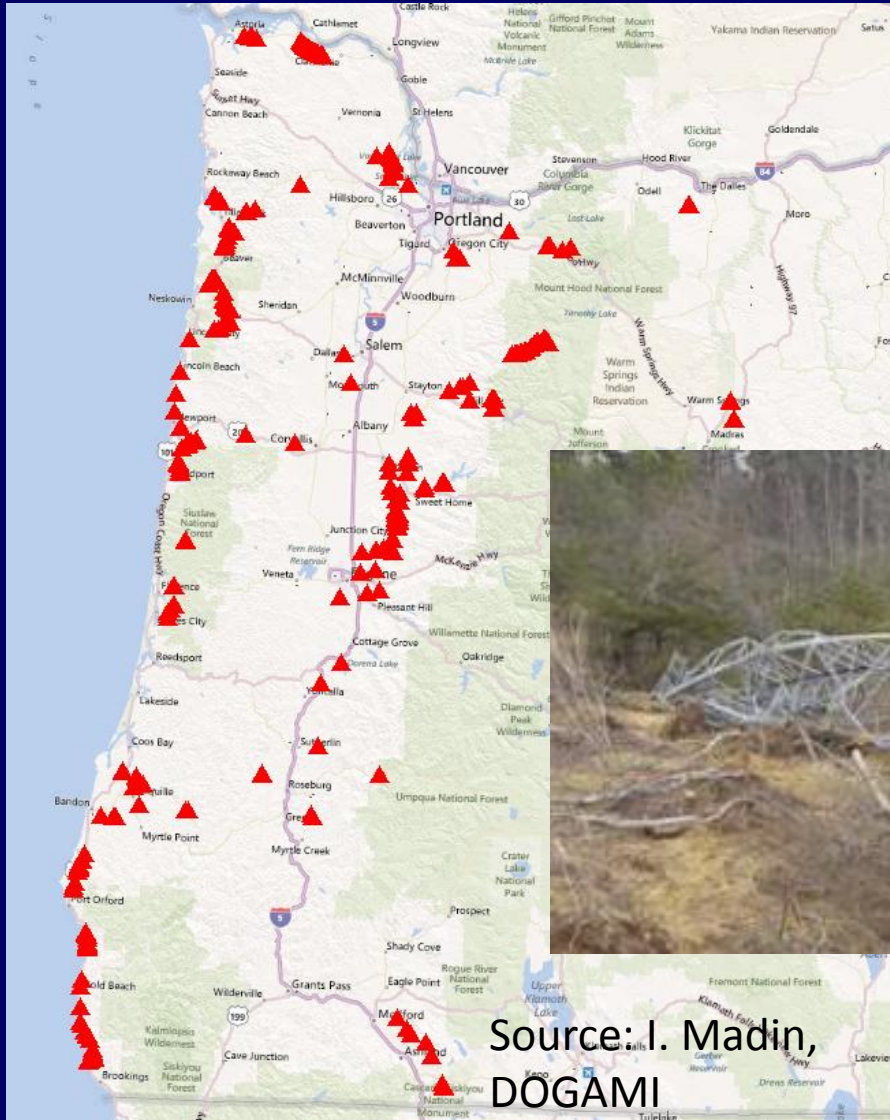


Risks by Sector: Electricity

- Electricity
 - Most electrical systems were not built to withstand earthquakes
 - Systems have high risk from shaking and ground movements
 - Systems include substations, switch stations, transmission lines, power plants, and key distribution substations
- Cascadia earthquake may cause regional blackout
- US DOE's BPA has seismic mitigation program



Towers with Ground Movement Hazard >1m



TEPCO Fukushima Damage

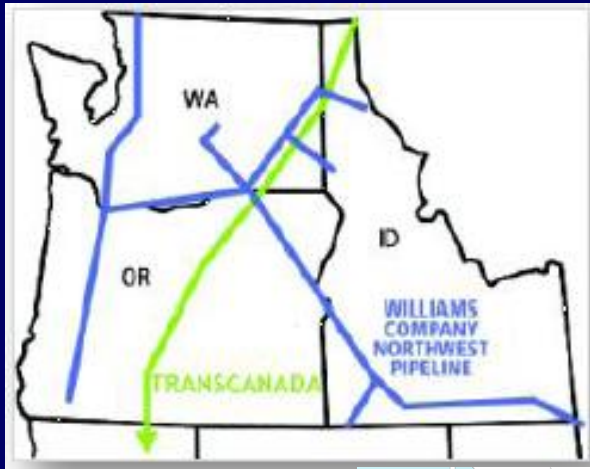
Source: www.infiniteunknown.net/2013/09/26/nuclear-experts-fukushima-reactor-no-4-spent-fuel-pool-shows-signs-of-collapsing/



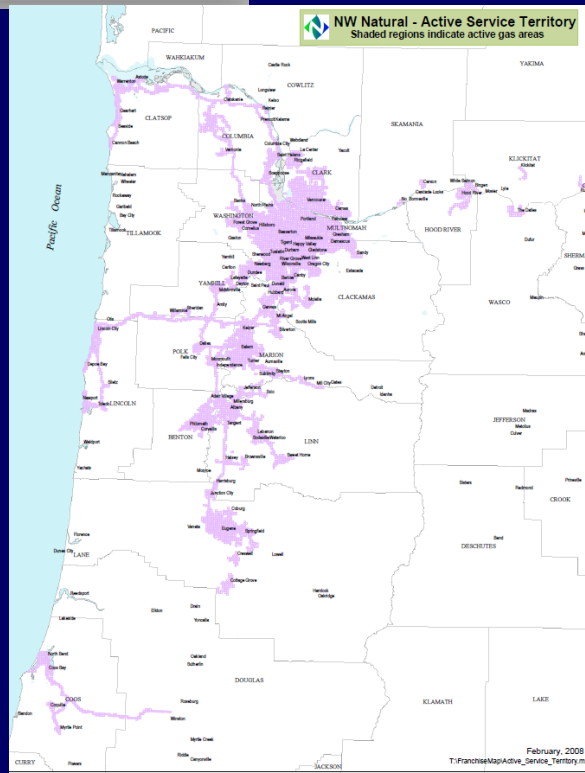
Source: I. Madin,
DOGAMI



Risks by Sector: Natural Gas



Source: ODOE, 2012

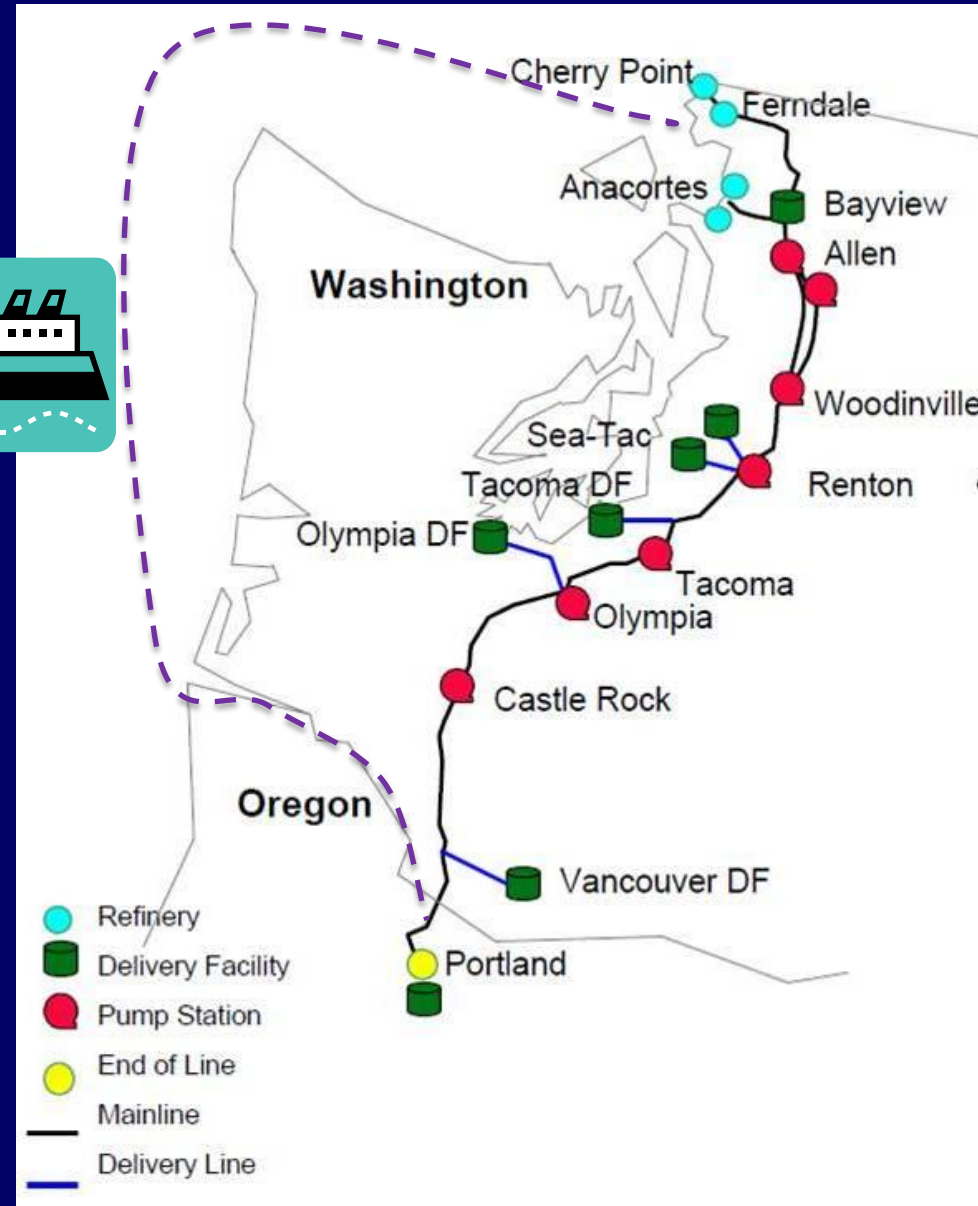


- Oregon's largest natural gas service provider receives the majority of their natural gas from pipelines that cross under Columbia River 1) near Sauvie Island, 2) between Washougal WA & Troutdale OR 3) near Clatskanie (W of PDX)
- These river crossing soils have high liquefaction hazards
- Pipe breaks could lead to natural gas shortfall, explosions or fires
- Storage capacity is limited



Risks by Sector: Liquid Fuel

- Refineries
- Delivery Systems
 - 1960s Transmission pipeline
 - Marine vessels
- Storage – Tank Farms
- (Distribution)

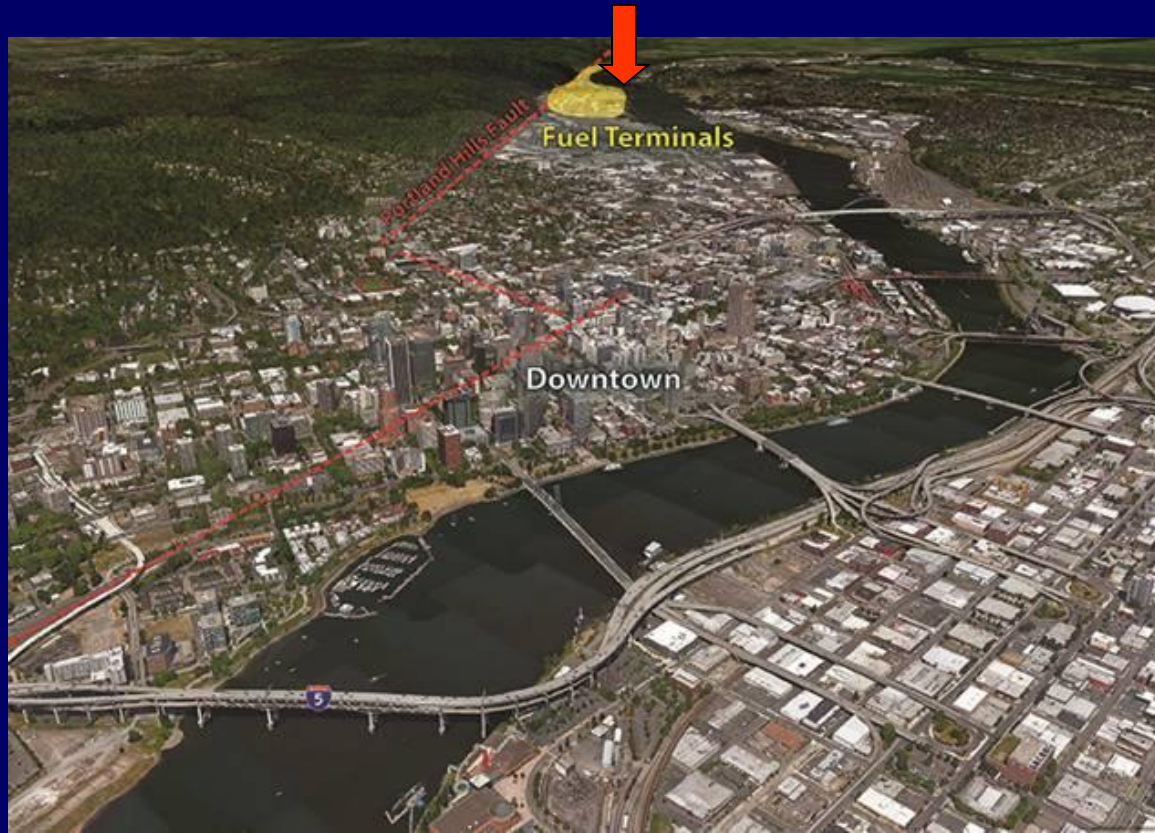


Source: DOGAMI O-13-9



Critical Energy Infrastructure (CEI) Hub

Area of Aggregated Risk of Key Importance
because >90% of Oregon's liquid fuel relies on it



Intersection of:

- **Liquid Fuel !**
- **Natural Gas**
- **Electric**
- **Liquefaction zone**

Oregon's Fuel Supply Facilities Built on High Liquefaction Hazard Soils



Source: Oregon
Historical Society

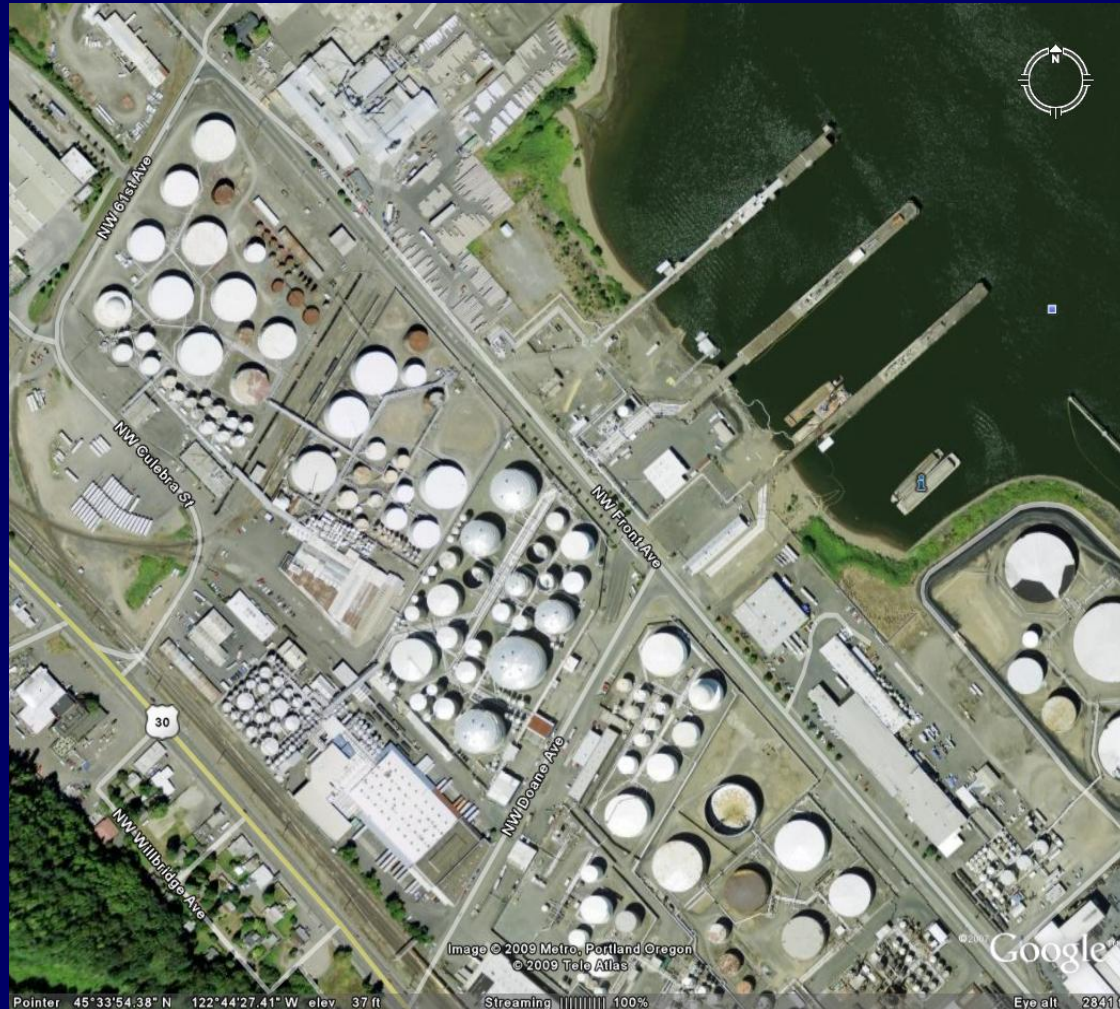


Source: Oregon
Historical Society



Source: DOGAMI O-13-9

Energy Facilities: Marine Oil Terminals, Tank Farms, River Crossings



Possible Damage to:

Docks: Structural, Foundation, Pipes, Cranes, Ships

Tanks: Structural, Foundation, Rigid Fittings, Floating equipment, Sloshing (5-10 ft high)

Buildings: Structural, non-structural, lifelines, SCADA

Structures/Equipment: Loading racks, containment, pipes, pipe racks, towers, lines, mechanical, electrical, telco



Marine Oil Terminals in Portland



Photos Credit:
Yumei Wang

June 2011, Yumei Wang, DOGAMI

Y Wang, DOGAMI, 2016



Marine Oil Terminals in Portland

- Many facilities built before seismic design codes & vulnerable
- Lots of Components & Interdependencies



Key Findings: Energy Sector

- **Energy Sector at High Risk & Low Resilience**
 - **Lots of Vulnerable Structures**
 - **Ground Development History: Highly Liquefiable Soils**
 - **Building Codes Inadequate (until 1994)**
 - **Requirements on Liquefiable Soils Inadequate (until 2004)**
- **Systems with Minimal Redundancy, & Many Interdependencies**
- **Expect extensive, prolonged disruption (unless mitigated)**
- **Recommendations: Analyze, Mitigate, Oversight on Progress**
- **Public-Private Partnership is needed**



Columbia River Crossings: Liquid Fuel, Natural Gas & Electricity



Photos Credit:
Yumei Wang

Critical Infrastructure Interdependencies

To restore electric service, you need to reopen roads



Source: ASCE TCLEE members

To restore water service, you need electricity



To restore fuel supplies you need electricity



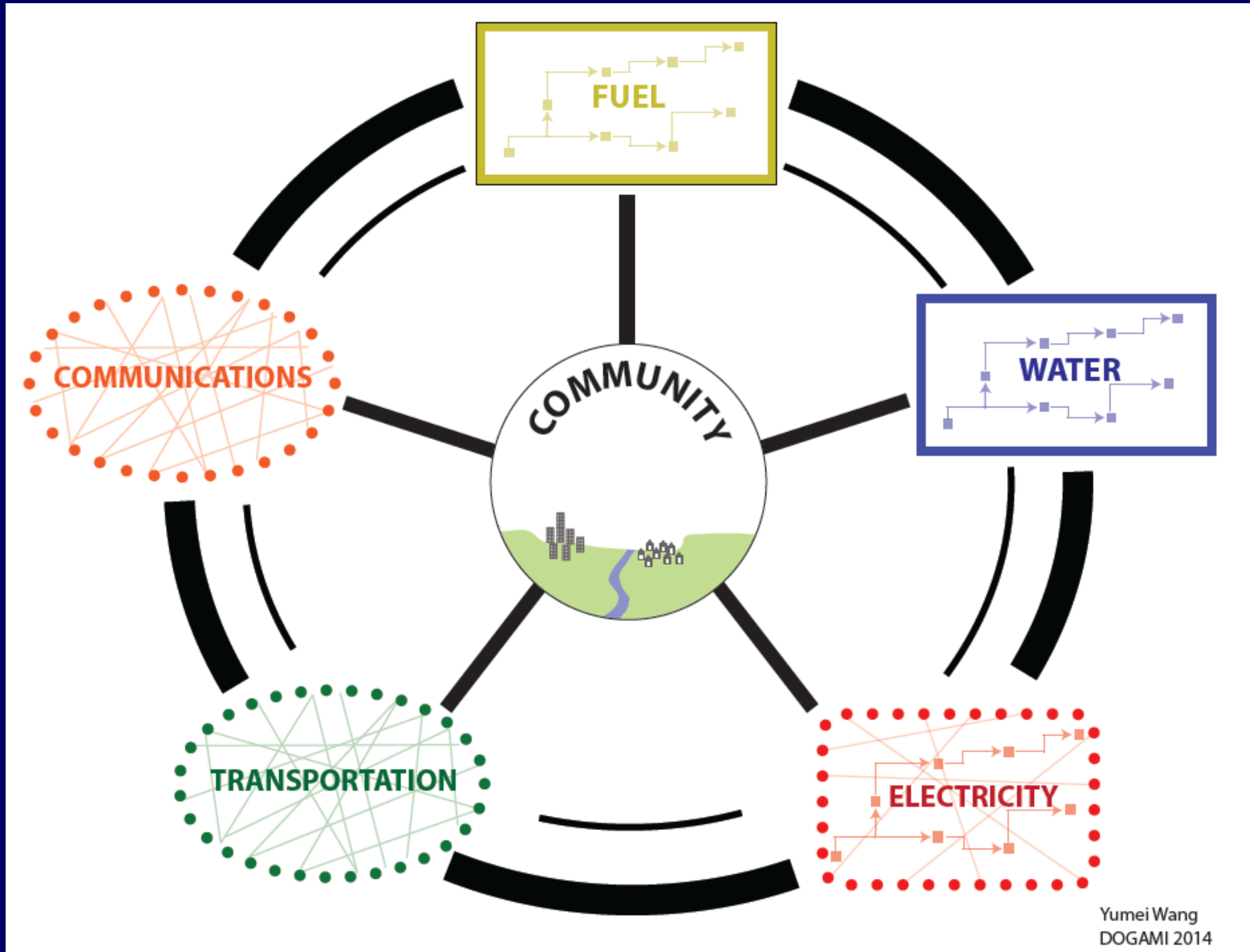
Source: ASCE TCLEE members

To reopen roads, you need to restore fuel supplies

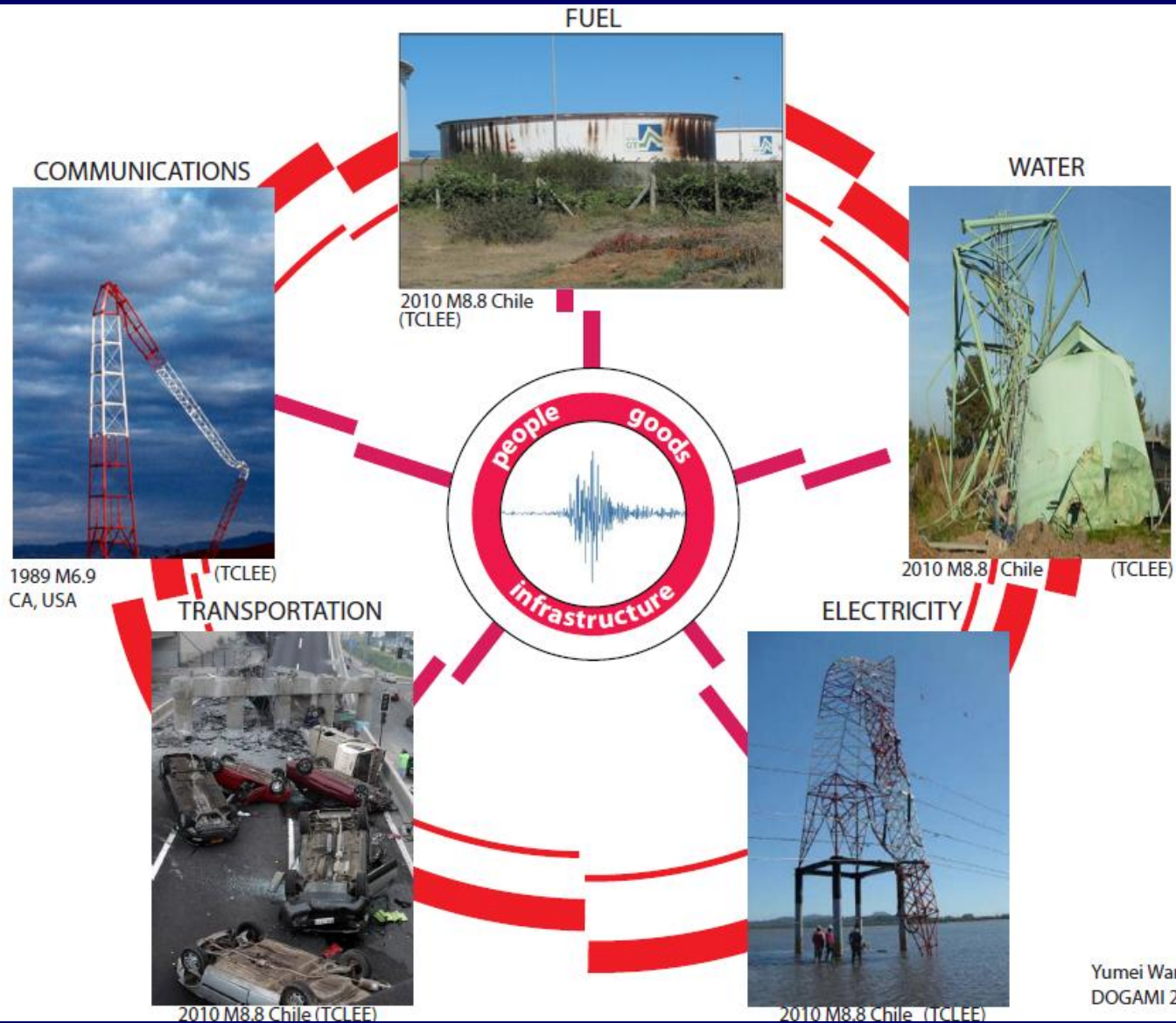


Source: ASCE TCLEE members

Lifelines: Community Interdependencies



Earthquakes Damage Lifelines



Yumei Wang
DOGAMI 2014

Emergency Lifeline Services



Questions?

www.oregongeology.org



Oshiokuri Hato Tsusen no Zu (Fast Cargo Boat Battling The Waves) 1805
<http://thesoundsinsidemymyhead.blogspot.com/2008/05/hokusais-great-wave.html>